

Dimethyl fumarate vs fingolimod following different pretreatments

A retrospective study

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Abstract

Objective

Despite frequent use of fingolimod (FTY) and dimethyl fumarate (DMF), studies comparing clinical efficacy and withdrawal rates of DMF and FTY concerning different pretreatment situations are rare. The aim of our study was to compare relapse occurrence and withdrawal rates of DMF and FTY in different pretreatment situations.

Methods

Patients from 4 European centers were retrospectively identified and followed until the 1st relapse after treatment start or if no relapse occurred for a maximum of 2 years. Cox regression analyses adjusted for relapsing-remitting MS (RRMS) disease duration, sex, and region were performed for the following pretreatment situations: treatment naive or injectables or DMF/FTY or natalizumab.

Results

Seven hundred thirty-two patients with RRMS (female/male: 2.4:1.0; DMF n = 409, FTY n = 323) were analyzed. Compared with FTY-treated patients, DMF-treated patients discontinued treatment more frequently mainly because of side effects (DMF/FTY: 29.3%/20.7%). Clinical relapses occurred in 24.5% of the patients within 24 months. Survival analysis demonstrated that compared with FTY treatment, DMF treatment was associated with an adjusted hazard ratio (aHR) for occurrence of relapse of 1.9 (95% CI 1.4–2.6, $p < 0.001$, n = 732). Stratification into pretreatment groups unmasked a higher relapse risk in DMF patients pretreated with natalizumab (aHR [95% CI] 4.5 [1.9–10.8], $p = 0.001$, n = 122) or to a lesser extend also in treatment-naïve patients (aHR [95% CI] 1.9 [1.01–3.6], $p = 0.045$, n = 230). No differences were observed in patients pretreated with injectables or the respective other oral drug (injectables: $p > 0.05$, n = 341; other oral: $p > 0.05$, n = 39).

Conclusions

DMF treatment was associated with higher clinical disease activity compared with FTY treatment. A subgroup analysis suggested beneficial effects of FTY in treatment-naïve and patients pretreated with natalizumab.

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Glossary

aHR = adjusted hazard ratio; **DMF** = dimethyl fumarate; **FTY** = fingolimod; **NEDA-3** = no evidence of disease activity-3; **RRMS** = relapsing-remitting MS.

Fingolimod (FTY) and dimethyl fumarate (DMF) are oral immunotherapies approved to treat patients with relapsing-remitting MS (RRMS).^{1,2} Several studies have retrospectively compared clinical efficacy between DMF and FTY, demonstrating mostly a similar efficacy.^{3–6} Moderate differences between DMF/FTY were present concerning MRI disease activity and treatment tolerability, which was superior in FTY-treated patients. In addition, focusing on the outcome parameter “no evidence of disease activity-3” (NEDA-3), which was reached in DMF- and FTY-treated patients with comparable frequencies, a subgroup analysis, however, unmasked a superiority of FTY in patients switching from self-injectable drugs to the respective oral substance.⁶ This different clinical efficacy was not present in treatment-naïve patients. Stratification into other pretreatment groups (e.g., pretreatment with natalizumab or the other oral drug) is missing.⁶

Our study will provide real-world data comparing discontinuation rates and clinical efficacy of DMF and FTY concerning the following pretreatment situations: treatment naïve, injectables, the other oral drug DMF or FTY, and natalizumab.

Methods

Patient groups studied

We conducted a retrospective observational study over 24 months including 732 patients with RRMS of the 4 participating European centers (figure) who had been treated with DMF ($n = 409$) or FTY ($n = 323$). Identification of eligible patients was performed using the following search terms “MS and fingolimod or Gilenya or FTY” in the centers Aarau, Athens, and Bern and “MS and Tecfidera or dimethyl fumarate or fumarate or DMF” in all 4 participating centers to search local clinical information systems within the following time frames for Bern, Aarau, and Athens January 2011–December 2018 and for Bochum January 2011–January 2016. No additional selection criteria were set. All patients identified with this search algorithm were included. MS diagnosis was in accordance with the 2010 McDonald criteria.⁷ Definition of clinical MS relapse followed national guidelines. The following variables were extracted from medical records: date of birth, year of MS diagnosis, sex, previous MS medication, date of the adverse event, date of drug withdrawal, date of treatment initiation of DMF or FTY, date of the 1st relapse under DMF or FTY treatment, or if no relapse during the 2-year follow-up occurred date of the last follow-up visit.

Statistical analysis

Categorical data are presented as frequencies and continuous data as means and 95% confidence intervals (95% CI) and

compared using for continuous variables Mann-Whitney test and for categorical variables χ^2 test. Survival analyses with the outcome “clinical relapse” were performed using Cox regression analysis adjusted for sex, RRMS disease duration, and region (Switzerland vs Europe). Survival analysis was performed for different pretreatments: (1) treatment naïve, (2) previous treatment with injectables (interferon or glatiramer acetate), (3) previous treatment with DMF or FTY, or (4) previous treatment with natalizumab. Level of significance was set to $p < 0.05$.

Ethical approvals

The respective ethic committees Aarau (2016-02233), Bern (2017-01369), Eginition Hospital Athens (1272018-511), and Bochum (5408-15) approved the analysis.

Data availability

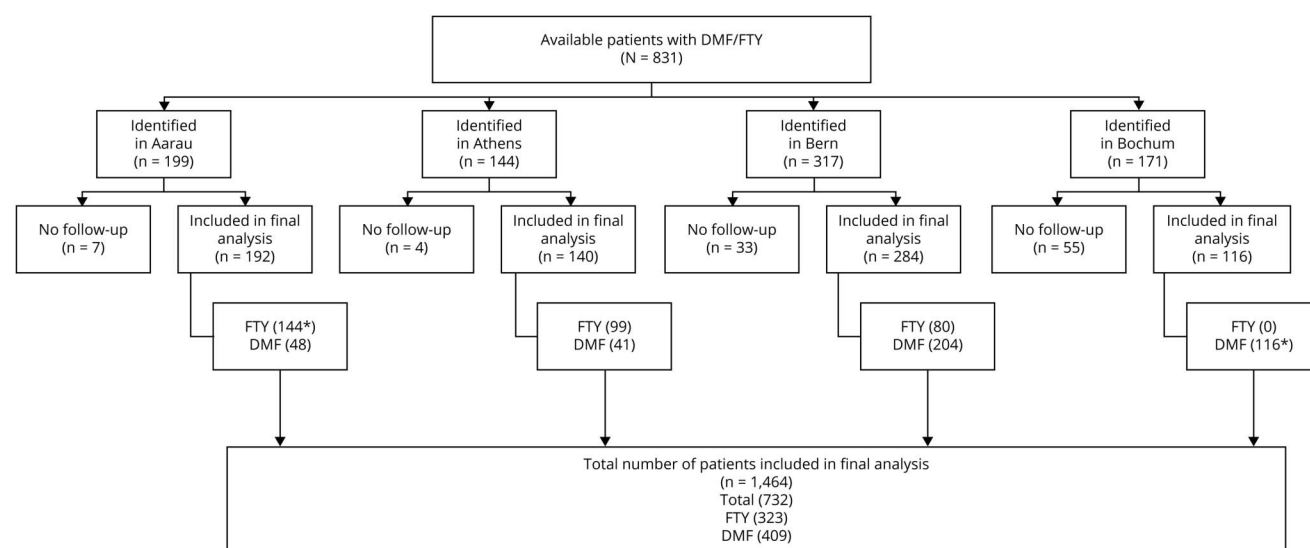
Anonymized source data are available on reasonable request via the corresponding author.

Results

Baseline demographics are shown in table 1. The primary reason for beginning with FTY was disease activity (DMF: 71/409, 17.4% vs FTY: 108/323, 33.4%, $p < 0.001$). Adverse events during previous immunotherapies were the main reason for beginning with DMF (DMF: 113/409, 27.6% vs FTY: 58/323, 18.0%, $p < 0.001$). Drug discontinuation was more common in DMF- than in FTY-treated patients (DMF: 120/409, 29.3% vs FTY: 67/323, 20.7%, $p = 0.008$). Adverse events were the most common reason for withdrawal (table 1). Despite clinical disease activity occurred in 20.4%–27.6% (FTY: 66/323 vs DMF: 113/409) of the patients, in only 33.6%–47.0% (DMF: 38/113 vs FTY: 31/66) of these patients, disease activity led to FTY/DMF withdrawal (table 1). The mean time to the 1st relapse was shorter in DMF-treated patients (years mean [95% CI]: DMF: 0.6 [0.5–0.6], $n = 113$ vs FTY: 1.0 [0.8–1.1], $n = 66$; $p < 0.001$), and this difference was the highest in the group pretreated with injectables (years mean [95% CI]: DMF: 0.6 [0.3–0.7], $n = 30$ vs FTY: 1.1 [0.9–1.3], $n = 42$; $p < 0.001$, table 1).

Compared with patients treated with FTY, patients treated with DMF had a higher adjusted hazard ratio (aHR) for occurrence of clinical relapse (aHR [95% CI] 1.9 [1.4–2.6], $p < 0.001$, $n = 732$, table 1). Stratification into pretreatment groups highlighted a higher relapse risk in DMF-treated patients pretreated with natalizumab (aHR [95% CI] 4.5 [1.9–10.8], $p = 0.001$, $n = 122$, table 1) or to a lesser extent in treatment-naïve patients (aHR [95% CI] 1.9 [1.01–3.6], $p = 0.045$, $n = 230$, table 1). No differences were observed in patients pretreated

Figure Study flowchart



Some patients of this cohort included in (1) Diem et al. TAND 2018 doi: 10.1177/1756286418791103 and (2) Miclea et al. J Neurol 2016 doi: 10.1007/s00415-016-8175-3. Locally used clinical information systems were i-pdos (Phoenix Technologies, Milpitas) in Bern, Orbis (Agfa HealthCare, Mortsel, Belgium) in Bochum, in-house "Demyelinating Diseases Database 1st Department of Neurology" in Athens, and KISIM (Cistec AG, Zürich, Switzerland) in Aarau. DMF = dimethyl fumarate; FTY = fingolimod.

with injectables or the respective other oral drug (injectables: $p > 0.05$, $n = 341$; other oral: $p > 0.05$, $n = 39$, table 1).

Discussion

We present a comparison of discontinuation rates and clinical efficacy data of DMF- and FTY-treated patients with RRMS over a follow-up period of 24 months. Taking advantage of the FTY label as 1st-line MS treatment in Switzerland, this study provides a unique patient population for head-to-head comparison of the clinical efficacy of DMF vs FTY in different pretreatment situations including treatment-naïve patients.⁸ In general, FTY appears to be less frequently withdrawn and clinically more effective in terms of relapse activity in our study. This increased clinical efficacy was present in treatment-naïve and in patients pretreated with natalizumab, whereas patients pretreated with injectables or switching from DMF to FTY or vice versa demonstrated to have an equal clinical response to treatment.

In line with previous reports, we demonstrated that discontinuation was more common in DMF- than in FTY-treated patients with adverse drug events being the main reason for drug withdrawal.⁵ Concerning disease activity, previous studies reported an equal efficacy^{3,4} or a trend toward a higher efficacy of FTY compared with DMF.^{5,6} The latter was also present in our study; however, our work provides additional evidence for different drug efficacy in regard to previous immunotherapy. Patients switching from natalizumab and to a lesser degree also treatment-naïve patients with MS benefitted from FTY in terms of the outcome "occurrence of

relapse", whereas no differences for occurrence of relapses were seen in patients pretreated with injectables or the respective other oral drug.

Prosperini et al.⁶ found a superiority of FTY in patients pretreated with injectables, whereas—different to ours—this was not present in treatment-naïve patients. Reasons for different findings may be the different end points used and the different drug labels of each study country. Prosperini et al.⁶ investigated NEDA-3 status, whereas our investigation purely focused on clinical relapses. Analysis of NEDA-3 status was not possible in our study because of different MRI protocols, frequencies of MRI assessments, and clinical visits between participating centers making a structured end point comparison for MRI and disability readouts prone to centrum biases.

The limitations of our retrospective study will be addressed in the following. Adjustment of the Cox regression analysis for each center was not possible because of small patient and event numbers in each single center, respectively (supplementary table 1, links.lww.com/NXI/A174), creating a limitation of our analysis. We therefore adjusted for region (Switzerland vs EU), as recommended in such cases by the European Medicine Agency.⁹ Adjustment for region is justified by the country-specific label of FTY considering 1st- (Switzerland) vs 2nd-line treatment (Europe: Germany and Greece), which might have had the greatest influence on our analysis.¹⁰ Patients were identified in the centers using predefined terms to search the existing local clinical information systems (figure). No other selection criteria were set. Whether in general, the setting of university and large academic MS centers creates a selection bias, cannot be

Table 1 Description of fingolimod (n = 323) or DMF (n = 409) treated patients and Cox regression models to predict clinical disease activity

	FTY	DMF	p Value
N (%)	323 (44.1)	409 (55.9)	
Centre, N (%)			
Aarau	144/323 (44.6)	48/409 (11.7)	NA
Athens	99/323 (30.7)	41/409 (10.0)	NA
Bern	80/323 (24.8)	204/409 (49.9)	NA
Bochum	0/323 (0.0)	116/409 (28.4)	NA
Female, N (%)	226/323 (70.0)	292/409 (71.4)	0.674
Age in years, mean (95% CI)	39.6 (37.5–40.0)	40.0 (38.8–41.2)	0.271
Disease duration in y, mean (95% CI)	6.8 (6.1–7.5)	5.9 (5.7–6.6)	0.001
MS treatment before DMF or FTY, N (%)			
Treatment naive	66/323 (20.4)	164/409(40.1)	<0.001
Injectables	183/323 (56.7)	158/409 (38.6)	<0.001
DMF	12/323 (3.7)	NA	NA
Fingolimod	NA	27/409 (6.6)	NA
Natalizumab	62/323 (19.2)	60/409 (14.7)	0.103
Primary reasons for beginning with DMF or FTY, N (%)			
PML risk during NTZ	79/323 (24.5)	52/409 (12.7)	<0.001
Medication adverse effects	58/323 (18.0)	113/409 (27.6)	<0.001
Disease activity	108/323 (33.4)	71/409 (17.4)	<0.001
Postpregnancy	1/323 (0.3)	1/409 (0.2)	0.980
Treatment naive	66/323 (20.4)	162/409 (39.6)	<0.001
Unknown	11/323 (3.4)	10/409 (2.4)	0.439
Discontinuation of DMF/FTY, N (%)	67/323 (20.7)	120/409 (29.3)	0.008
Disease activity	31/323 (9.6)	38/409 (9.3)	0.888
Medication adverse effects	27/323 (8.4)	64/409 (15.6)	0.005
Pregnancy	4/323 (1.2)	9/409 (2.2)	0.328
Unknown	5/323 (1.5)	9/409 (2.2)	0.522
Mean time to discontinuation of DMF/FTY, y (95% CI)	1.5 (1.2–1.8)	0.8 (0.7–1.0)	<0.001
Treatment naive	0.8 (0.5–1.1)	0.7 (0.5–0.9)	0.157
Injectables	2.0 (1.5–2.5)	1.1 (0.7–1.4)	0.005
Other oral (e.g., DMF → FTY)	1.1 (0.5–1.7)	1.0 (0.2–1.7)	0.307
Natalizumab	0.8 (0.3–1.5)	0.8 (0.3–1.1)	0.905
Clinical relapse within 12 mo, N (%)	37/323 (11.5)	95/409 (23.2)	<0.001
Clinical relapse within 24 mo, N (%)	66/323 (20.4)	113/409 (27.6)	0.025
Mean time to first relapse in y, mean (95% CI)	1.0 (0.8–1.1)	0.6 (0.5–0.6)	<0.001
Treatment naive	0.8 (0.5–1.1)	0.6 (0.5–0.7)	0.375
Injectables	1.1 (0.9–1.3)	0.6 (0.3–0.7)	<0.001

Continued

Table 1 Description of fingolimod (n = 323) or DMF (n = 409) treated patients and Cox regression models to predict clinical disease activity (continued)

	FTY	DMF	p Value
Other oral (e.g., DMF → FTY)	0.9 (−1.1–3.1)	0.6 (0.1–1.2)	0.865
Natalizumab	0.5 (0.0–3.0)	0.4 (0.2–0.6)	0.979

	aHR (95% CI)	N	p Value
All patients	1.9 (1.4–2.6)	732	<0.001
Treatment naive	1.9 (1.01–3.6)	230	0.045
Injectables	1.5 (0.9–2.5)	341	0.085
Other oral (e.g., DMF → FTY)	1.4 (0.2–8.3)	39	0.736
Natalizumab	4.5 (1.9–10.8)	122	0.001

Abbreviations: aHR = adjusted hazard ratio; DMF = dimethyl fumarate; DMT = disease-modifying treatment; EU = European Union; FTY = fingolimod; injectables = interferon or glatiramer acetate; NA = not applicable; NTZ = natalizumab; PML = progressive multifocal leukoencephalopathy. Statistics: for continuous variables, the Mann-Whitney test was used, and for categorical variables, the χ^2 test was used. Cox regression was adjusted for sex, disease duration, and region (Switzerland vs EU). aHRs are displayed for DMF compared with fingolimod. Significant p values are written in bold letters. Clinical information systems in use were i-pdos (Phoenix Technologies, Milpitas) in Bern, Orbis (Agfa HealthCare, Mortsel, Belgium) in Bochum, in-house "Demyelinating Diseases Database of 1st Department of Neurology" in Athens, and KISIM (Cistec AG, Zürich, Switzerland) in Aarau.

sufficiently answered, and should be kept in mind when interpreting our data.

In addition, other limitations are the relatively small sample size in the group pretreated with DMF or FTY and the nonstandardized treatment approach within the 4 participating centers, e.g., different washout periods between medication switch, different intervals of MRI, and clinical investigations. However, as we present a real-world study, the latter limitation, which interferes with data analysis, mainly reflects the clinical situation of most neurologists treating patients with MS.

Considering the growing armamentarium of immunotherapies for patients with MS and the known effects of medication withdrawal and switch during MS disease course, our study, which provides evidence for decision-making processes, may guide physicians throughout clinically challenging treatment options.

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Disclosure

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Appendix Authors

Name	Location	Role	Contribution
Lara Diem, MD	Inselspital University Hospital and University of Bern, Bern, Switzerland	Author	Contributed to the design of the study, acquisition of data, analysis and interpretation of the data, and writing and revision of the manuscript

Continued

Appendix (continued)

Name	Location	Role	Contribution
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Ralf Gold, MD	St. Josef Hospital Ruhr University Bochum, Bochum, Germany	Author	Contributed to the acquisition of data and revised the manuscript for intellectual content
Constantinos Kilidireas, MD	Eginition University Hospital, National and Kapodistrian University of Athens, Athens, Greece	Author	Contributed significantly to the data analysis and digitalization during the review process

Appendix (continued)

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Andrew Chan, MD	Inselspital University Hospital and University of Bern, Bern, Switzerland	Author	Contributed to the interpretation of the data and the writing and revision of the manuscript
Maria Eleftheria Evangelopoulos, MD	Eginition University Hospital, National and Kapodistrian University of Athens, Athens, Greece	Author	Contributed to the design of the study, acquisition of data, analysis and interpretation of the data, and writing and revision of the manuscript
Robert Hoepner, MD	Inselspital University Hospital and University of Bern, Bern, Switzerland	Author	Contributed to the design of the study, acquisition of data, analysis and interpretation of the data, and writing and revision of the manuscript

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